

Nathan Wemmer

Code ▾

Chapter 11 - Assignment 9

Section 11.1

Section 11.1.2

Section 11.1.3

Hide

```
setwd("C:/Users/Nathan/Desktop/school/statistical data management/therbook")
results <- read.table("yields.txt",header=T)
attach(results)
names(results)
```

```
[1] "sand" "clay" "loam"
```

Hide

results

	sand<int>	clay<int>	loam<int>
	6	17	13
	10	15	16
	8	3	9
	6	11	12
	14	14	15
	17	12	16
	9	12	17
	11	8	13
	7	10	18
	11	13	14
1-10 of 10 rows			

Hide

```
sapply(list(sand,clay,loam),mean)
```

```
[1] 9.9 11.5 14.3
```

Hide

```
(frame <- stack(results))
```

	values	ind
	<int>	<fctr>
	6	sand
	10	sand
	8	sand
	6	sand
	14	sand
	17	sand
	9	sand
	11	sand
	7	sand
	11	sand

1-10 of 30 rows

Previous123Next

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```
names(frame) <- c("yield","soil")
attach(frame)
head(frame)
```

	yield	soil
	<int>	<fctr>
1	6	sand
2	10	sand
3	8	sand
4	6	sand
5	14	sand
6	17	sand

6 rows

Hide

```
tapply(yield,soil,var)
```

```
      sand      clay      loam  
12.544444 15.388889  7.122222
```

Hide

```
#fligner.test(y~soil)  
fligner.test(yield~soil)
```

Fligner-Killeen test of homogeneity of variances

data: yield by soil
Fligner-Killeen:med chi-squared = 0.36507, df = 2,
p-value = 0.8332

Hide

```
plot(yield~soil,col="green")  
sum((yield-mean(yield))^2)
```

```
[1] 414.7
```

Hide

```
sand-mean(sand)
```

```
[1] -3.9  0.1 -1.9 -3.9  4.1  7.1 -0.9  1.1 -2.9  1.1
```

Hide

```
clay-mean(clay)
```

```
[1]  5.5  3.5 -8.5 -0.5  2.5  0.5  0.5 -3.5 -1.5  1.5
```

Hide

```
loam-mean(loam)
```

```
[1] -1.3  1.7 -5.3 -2.3  0.7  1.7  2.7 -1.3  3.7 -0.3
```

Hide

```
sum((sand-mean(sand))^2)
```

```
[1] 112.9
```

[Hide](#)

```
sum((clay-mean(clay))^2)
```

```
[1] 138.5
```

[Hide](#)

```
sum((loam-mean(loam))^2)
```

```
[1] 64.1
```

[Hide](#)

```
sum(sapply(list(sand,clay,loam),function (x) sum((x-mean(x))^2) ))
```

```
[1] 315.5
```

[Hide](#)

```
tapply(yield,soil,var)
```

```
      sand      clay      loam  
12.544444 15.388889  7.122222
```

[Hide](#)

```
mean(tapply(yield,soil,var))
```

```
[1] 11.68519
```

[Hide](#)

```
qf(.95,2,27)
```

```
[1] 3.354131
```

[Hide](#)

```
1-pf(4.24,2,27)
```

```
[1] 0.02503987
```

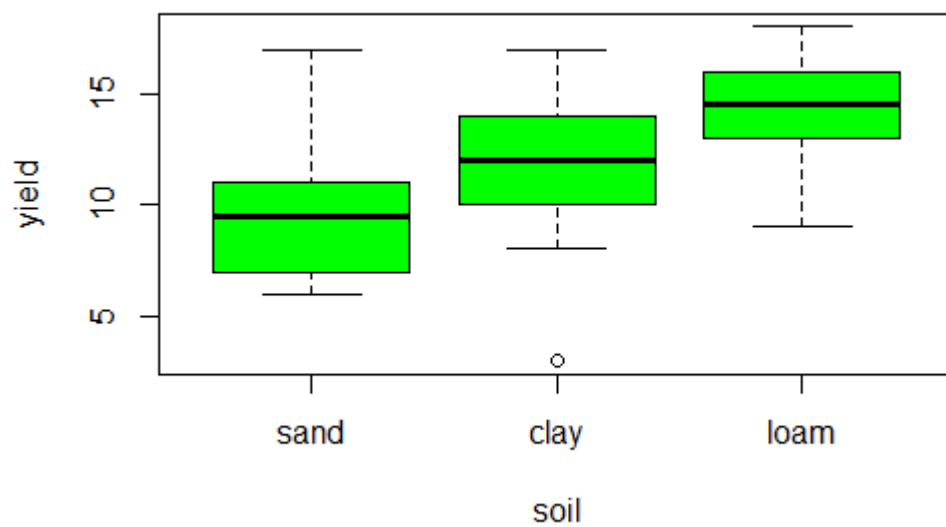
Hide

```
summary(aov(yield~soil))
```

```
          Df Sum Sq Mean Sq F value Pr(>F)
soil         2   99.2   49.60   4.245  0.025 *
Residuals    27  315.5   11.69
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

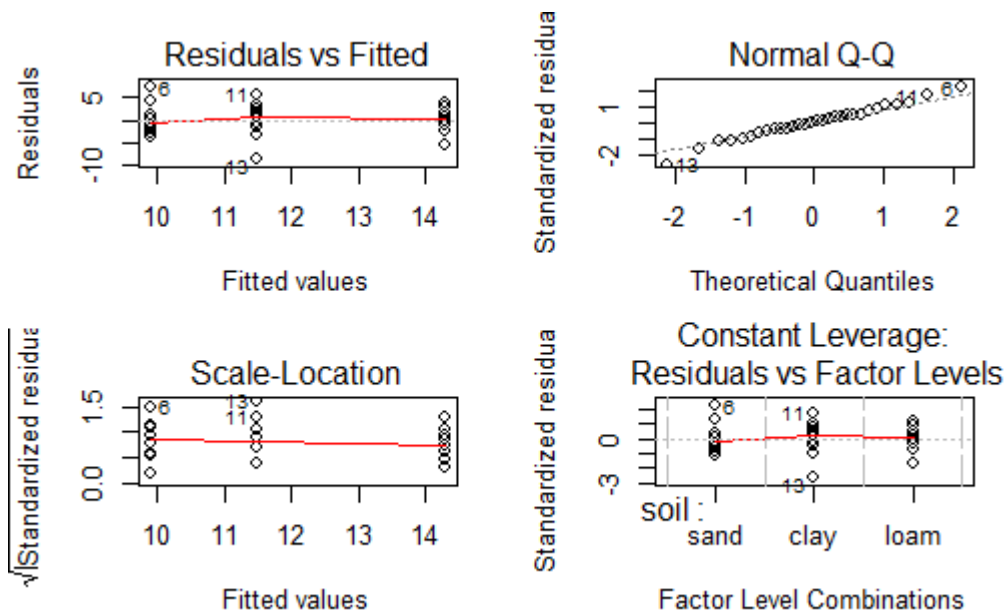
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```
par(mfrow=c(2,2))
```



Hide

```
plot(aov(yield~soil))
```



Section 11.1.4

[Hide](#)

```
model <- aov(yield~soil)
model.tables(model, se=T)
```

Tables of effects

```
soil
soil
sand clay loam
-2.0 -0.4 2.4
```

Standard errors of effects

```
soil
1.081
replic. 10
```

[Hide](#)

```
model.tables(model, "means", se=T)
```

Tables of means

Grand mean

11.9

soil

soil

sand clay loam

9.9 11.5 14.3

Standard errors for differences of means

soil

1.529

replic. 10

Hide

summary.lm(model)

Call:

aov(formula = yield ~ soil)

Residuals:

Min	1Q	Median	3Q	Max
-8.5	-1.8	0.3	1.7	7.1

Coefficients:

	Estimate	Std. Error	t value	Pr(> t)
(Intercept)	9.900	1.081	9.158	9.04e-10 ***
soilclay	1.600	1.529	1.047	0.30456
soilloam	4.400	1.529	2.878	0.00773 **

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Residual standard error: 3.418 on 27 degrees of freedom

Multiple R-squared: 0.2392, Adjusted R-squared: 0.1829

F-statistic: 4.245 on 2 and 27 DF, p-value: 0.02495

Hide

qt(0.975,18)

[1] 2.100922

Hide

2*(1 - pt(2.88, df = 18))

```
[1] 0.009966426
```

Section 11.1.5

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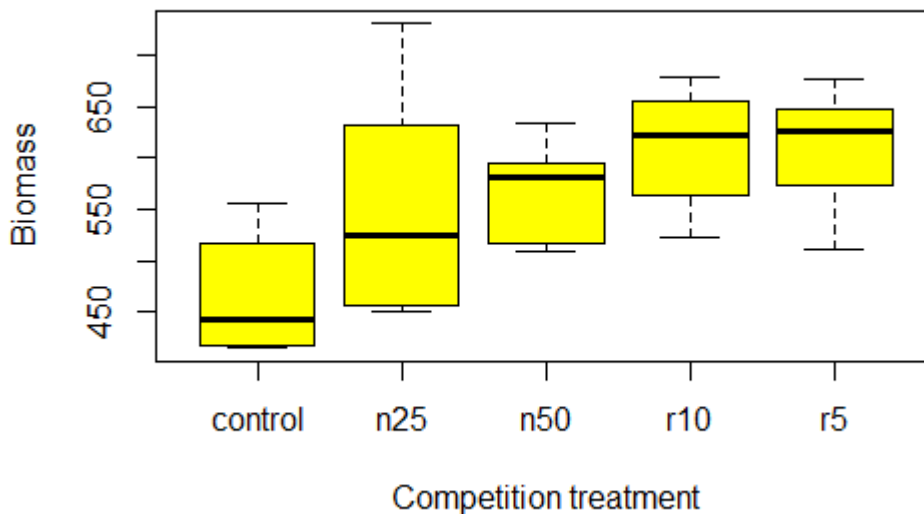
```
setwd("C:/Users/Nathan/Desktop/school/statistical data management/therbook")
comp <- read.table("competition.txt",header=T)
```

```
attach(comp)
names(comp)
```

```
[1] "biomass" "clipping"
```

Hide

```
plot(clipping,biomass,xlab="Competition treatment",
     ylab="Biomass",col="yellow")
```



Hide

```
error.bars <- function(yv,z,nn)
{
  xv <- barplot(yv,ylim=c(0,(max(yv)+max(z))),
               col="green",names=nn,ylab=deparse(substitute(yv)))
  for (i in 1:length(xv)) {
    arrows(xv[i],yv[i]+z[i],xv[i],yv[i]-z[i],angle=90,code=3,length=0.15)
  }
}

model <- aov(biomass~clipping)
summary(model)
```



```

      Df Sum Sq Mean Sq F value    Pr(>F)
clipping    4  85356    21339    4.302 0.00875 **
Residuals   25 124020     4961
---
Signif. codes:
  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

Hide

```
table(clipping)
```

```

clipping
control    n25    n50    r10    r5
      6      6      6      6      6

```

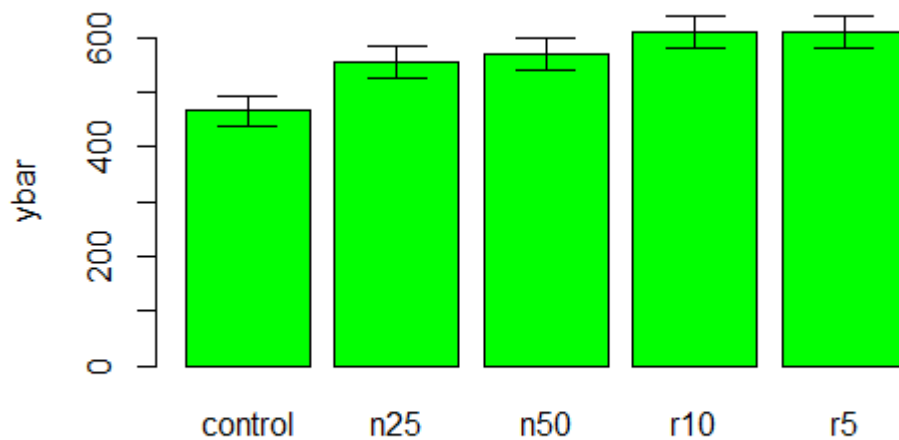
Hide

```

se <- rep(28.75,5)

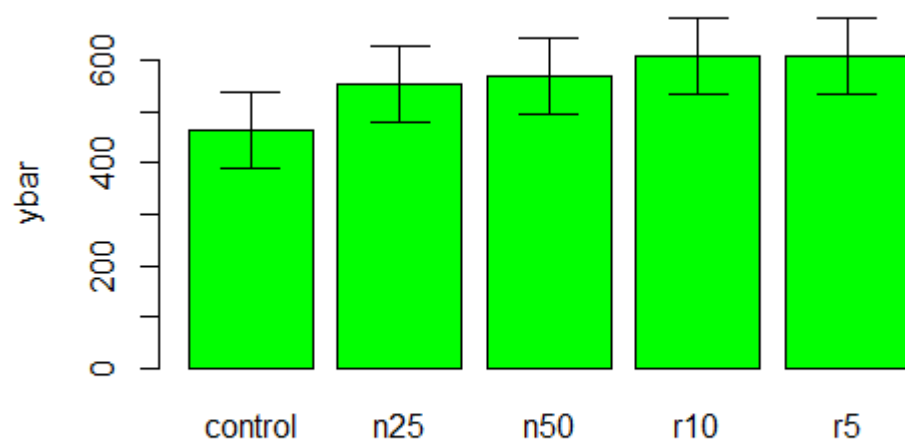
labels <- levels(clipping)
ybar <- tapply(biomass,clipping,mean)
error.bars(ybar,se,labels)

```



Hide

```
error.bars(ybar,2.570582*se,labels)
```



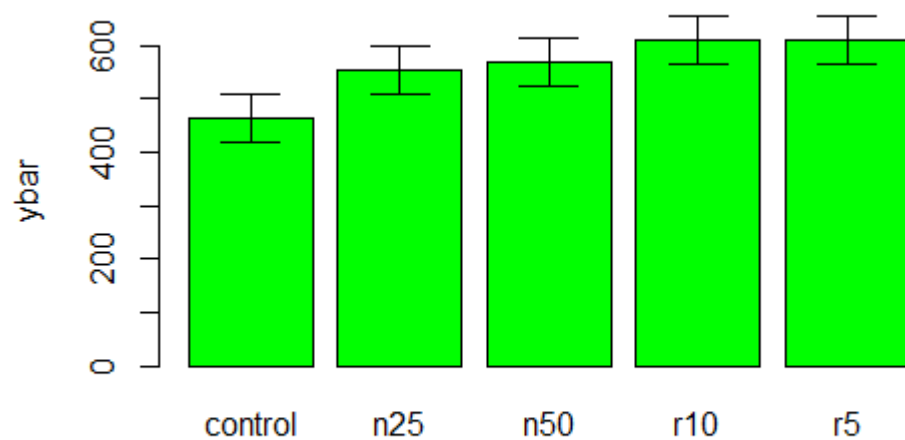
Hide

```
qt(0.975,10)*sqrt(2*4961/6)
```

```
[1] 90.60794
```

Hide

```
lsd <- qt(0.975,10)*sqrt(2*4961/6)
lsdbars <- rep(lsd,5)/2
error.bars(ybar,lsdbars,labels)
```



Section 11.2

Hide

```
setwd("C:/Users/Nathan/Desktop/school/statistical data management/therbook")
weights <- read.table("growth.txt",header=T)
attach(weights)
```

The following objects are masked from weights (pos = 3):

diet, gain, supplement

The following objects are masked from weights (pos = 4):

diet, gain, supplement

The following objects are masked from weights (pos = 10):

diet, gain, supplement

The following objects are masked from weights (pos = 11):

diet, gain, supplement

The following objects are masked from weights (pos = 12):

diet, gain, supplement

[Hide](#)

```
labs <- c("Barley","Oats","Wheat")
legend(locator(1),labs,fill= c("orange","yellow","cornsilk"))
```

Error in locator(1) : plot.new has not been called yet

Section 11.3

[Hide](#)

```
yields <- read.table("splityield.txt",header=T)
```

```
attach(yields)
```

The following object is masked from frame:

yield

[Hide](#)

```
names(yields)
```

```
[1] "yield"      "block"      "irrigation" "density"
[5] "fertilizer"
```

Hide

```
model <-
  aov(yield~irrigation*density*fertilizer+Error(block/irrigation/density))
summary(model)
```

```
Error: block
      Df Sum Sq Mean Sq F value Pr(>F)
Residuals  3  194.4    64.81

Error: block:irrigation
      Df Sum Sq Mean Sq F value Pr(>F)
irrigation  1   8278    8278   17.59 0.0247 *
Residuals   3   1412     471

---
Signif. codes:
  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Error: block:irrigation:density
      Df Sum Sq Mean Sq F value Pr(>F)
density      2   1758    879.2   3.784 0.0532 .
irrigation:density  2   2747   1373.5   5.912 0.0163 *
Residuals     12   2788    232.3

---
Signif. codes:
  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

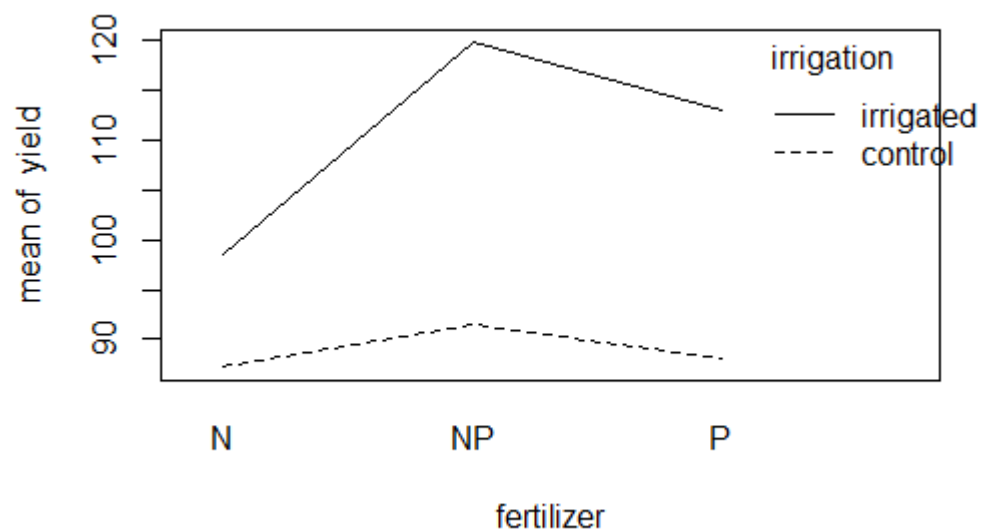
Error: Within
      Df Sum Sq Mean Sq F value
fertilizer      2  1977.4    988.7  11.449
irrigation:fertilizer  2   953.4    476.7   5.520
density:fertilizer    4   304.9     76.2   0.883
irrigation:density:fertilizer  4   234.7     58.7   0.680
Residuals        36  3108.8     86.4

      Pr(>F)
fertilizer      0.000142 ***
irrigation:fertilizer  0.008108 **
density:fertilizer    0.484053
irrigation:density:fertilizer 0.610667
Residuals

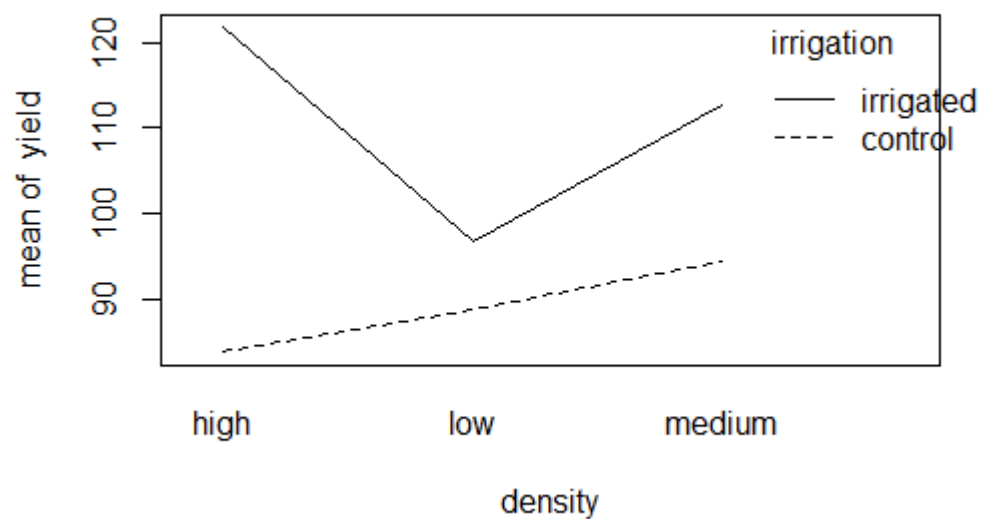
---
Signif. codes:
  0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Hide

```
interaction.plot(fertilizer,irrigation,yield)
```


[Hide](#)

```
interaction.plot(density,irrigation,yield)
```


[Hide](#)

```
rats <- read.table("rats.txt",header=T)
```

```
attach(rats)
names(rats)
```

```
[1] "Glycogen" "Treatment" "Rat"      "Liver"
```

Hide

```
Treatment <- factor(Treatment)
Rat <- factor(Rat)
Liver <- factor(Liver)

model <- aov(Glycogen~Treatment)
summary(model)
```

```
          Df Sum Sq Mean Sq F value    Pr(>F)
Treatment   2   1558    778.8    14.5 3.03e-05 ***
Residuals  33   1773     53.7
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

Hide

```
(means <- tapply(Glycogen,list(Treatment,Rat),mean))
```

```
      1      2
1 132.5000 148.5000
2 149.6667 152.3333
3 134.3333 136.0000
```

Hide

```
treat <- gl(3,1,length=6)
model <- aov(as.vector(means)~treat)
summary(model)
```

```
          Df Sum Sq Mean Sq F value    Pr(>F)
treat      2   259.6    129.80     2.929   0.197
Residuals  3   132.9     44.31
```

Hide

```
model2 <- aov(Glycogen~Treatment+Error(Treatment/Rat/Liver))
summary(model2)
```

Error: Treatment

	Df	Sum Sq	Mean Sq
Treatment	2	1558	778.8

Error: Treatment:Rat

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	3	797.7	265.9		

Error: Treatment:Rat:Liver

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	12	594	49.5		

Error: Within

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Residuals	18	381	21.17		

[Hide](#)

```
varcomps <- c(21.17,14.165,36.065)
100*varcomps/sum(varcomps)
```

```
[1] 29.64986 19.83894 50.51120
```

Section 11.5

[Hide](#)

```
daphnia <- read.table("Daphnia.txt",header=T)
```

```
attach(daphnia)
names(daphnia)
```

```
[1] "Growth.rate" "Water"          "Detergent"    "Daphnia"
```

[Hide](#)

```
model1 <- aov(Growth.rate~Water*Detergent*Daphnia)
summary(model1)
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Water	1	1.99	1.985	2.850	0.097838
Detergent	3	2.21	0.737	1.059	0.375478
Daphnia	2	39.18	19.589	28.128	8.23e-09
Water:Detergent	3	0.17	0.058	0.084	0.968608
Water:Daphnia	2	13.73	6.866	9.859	0.000259
Detergent:Daphnia	6	20.60	3.433	4.930	0.000532
Water:Detergent:Daphnia	6	5.85	0.975	1.399	0.234324
Residuals	48	33.43	0.696		

Water	.
Detergent	
Daphnia	***
Water:Detergent	
Water:Daphnia	***
Detergent:Daphnia	***
Water:Detergent:Daphnia	
Residuals	

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

[Hide](#)

```
model2 <- lm(Growth.rate~Water*Detergent*Daphnia)
summary(model2)
```


Call:

```
lm(formula = Growth.rate ~ Water * Detergent * Daphnia)
```

Residuals:

Min	1Q	Median	3Q	Max
-1.4882	-0.5440	0.0239	0.3560	1.5250

Coefficients:

	Estimate	Std. Error
(Intercept)	2.81126	0.48181
WaterWear	-0.15808	0.68138
DetergentBrandB	-0.03536	0.68138
DetergentBrandC	0.47626	0.68138
DetergentBrandD	-0.21407	0.68138
DaphniaClone2	0.49637	0.68138
DaphniaClone3	2.05526	0.68138
WaterWear:DetergentBrandB	0.46455	0.96361
WaterWear:DetergentBrandC	-0.27431	0.96361
WaterWear:DetergentBrandD	0.21729	0.96361
WaterWear:DaphniaClone2	1.38081	0.96361
WaterWear:DaphniaClone3	0.43156	0.96361
DetergentBrandB:DaphniaClone2	0.91892	0.96361
DetergentBrandC:DaphniaClone2	-0.16337	0.96361
DetergentBrandD:DaphniaClone2	1.01209	0.96361
DetergentBrandB:DaphniaClone3	-0.06490	0.96361
DetergentBrandC:DaphniaClone3	-0.80789	0.96361
DetergentBrandD:DaphniaClone3	-1.28669	0.96361
WaterWear:DetergentBrandB:DaphniaClone2	-1.26380	1.36275
WaterWear:DetergentBrandC:DaphniaClone2	1.35612	1.36275
WaterWear:DetergentBrandD:DaphniaClone2	0.77616	1.36275
WaterWear:DetergentBrandB:DaphniaClone3	-0.87443	1.36275
WaterWear:DetergentBrandC:DaphniaClone3	-1.03019	1.36275
WaterWear:DetergentBrandD:DaphniaClone3	-1.55400	1.36275

	t value	Pr(> t)
(Intercept)	5.835	4.48e-07
WaterWear	-0.232	0.81753
DetergentBrandB	-0.052	0.95883
DetergentBrandC	0.699	0.48794
DetergentBrandD	-0.314	0.75475
DaphniaClone2	0.728	0.46986
DaphniaClone3	3.016	0.00408
WaterWear:DetergentBrandB	0.482	0.63193
WaterWear:DetergentBrandC	-0.285	0.77712
WaterWear:DetergentBrandD	0.225	0.82255
WaterWear:DaphniaClone2	1.433	0.15835
WaterWear:DaphniaClone3	0.448	0.65627
DetergentBrandB:DaphniaClone2	0.954	0.34506
DetergentBrandC:DaphniaClone2	-0.170	0.86609
DetergentBrandD:DaphniaClone2	1.050	0.29884
DetergentBrandB:DaphniaClone3	-0.067	0.94658
DetergentBrandC:DaphniaClone3	-0.838	0.40597
DetergentBrandD:DaphniaClone3	-1.335	0.18809

```

WaterWear:DetergentBrandB:DaphniaClone2 -0.927 0.35837
WaterWear:DetergentBrandC:DaphniaClone2 0.995 0.32466
WaterWear:DetergentBrandD:DaphniaClone2 0.570 0.57164
WaterWear:DetergentBrandB:DaphniaClone3 -0.642 0.52414
WaterWear:DetergentBrandC:DaphniaClone3 -0.756 0.45337
WaterWear:DetergentBrandD:DaphniaClone3 -1.140 0.25980

```

```

(Intercept) ***

```

```

WaterWear

```

```

DetergentBrandB

```

```

DetergentBrandC

```

```

DetergentBrandD

```

```

DaphniaClone2

```

```

DaphniaClone3 **

```

```

WaterWear:DetergentBrandB

```

```

WaterWear:DetergentBrandC

```

```

WaterWear:DetergentBrandD

```

```

WaterWear:DaphniaClone2

```

```

WaterWear:DaphniaClone3

```

```

DetergentBrandB:DaphniaClone2

```

```

DetergentBrandC:DaphniaClone2

```

```

DetergentBrandD:DaphniaClone2

```

```

DetergentBrandB:DaphniaClone3

```

```

DetergentBrandC:DaphniaClone3

```

```

DetergentBrandD:DaphniaClone3

```

```

WaterWear:DetergentBrandB:DaphniaClone2

```

```

WaterWear:DetergentBrandC:DaphniaClone2

```

```

WaterWear:DetergentBrandD:DaphniaClone2

```

```

WaterWear:DetergentBrandB:DaphniaClone3

```

```

WaterWear:DetergentBrandC:DaphniaClone3

```

```

WaterWear:DetergentBrandD:DaphniaClone3

```

```

---
```

```

Signif. codes:

```

```

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.8345 on 48 degrees of freedom

```

```

Multiple R-squared: 0.7147, Adjusted R-squared: 0.578

```

```

F-statistic: 5.227 on 23 and 48 DF, p-value: 7.019e-07

```

[Hide](#)

```
summary.lm(model1)
```

Call:

```
aov(formula = Growth.rate ~ Water * Detergent * Daphnia)
```

Residuals:

Min	1Q	Median	3Q	Max
-1.4882	-0.5440	0.0239	0.3560	1.5250

Coefficients:

	Estimate	Std. Error
(Intercept)	2.81126	0.48181
WaterWear	-0.15808	0.68138
DetergentBrandB	-0.03536	0.68138
DetergentBrandC	0.47626	0.68138
DetergentBrandD	-0.21407	0.68138
DaphniaClone2	0.49637	0.68138
DaphniaClone3	2.05526	0.68138
WaterWear:DetergentBrandB	0.46455	0.96361
WaterWear:DetergentBrandC	-0.27431	0.96361
WaterWear:DetergentBrandD	0.21729	0.96361
WaterWear:DaphniaClone2	1.38081	0.96361
WaterWear:DaphniaClone3	0.43156	0.96361
DetergentBrandB:DaphniaClone2	0.91892	0.96361
DetergentBrandC:DaphniaClone2	-0.16337	0.96361
DetergentBrandD:DaphniaClone2	1.01209	0.96361
DetergentBrandB:DaphniaClone3	-0.06490	0.96361
DetergentBrandC:DaphniaClone3	-0.80789	0.96361
DetergentBrandD:DaphniaClone3	-1.28669	0.96361
WaterWear:DetergentBrandB:DaphniaClone2	-1.26380	1.36275
WaterWear:DetergentBrandC:DaphniaClone2	1.35612	1.36275
WaterWear:DetergentBrandD:DaphniaClone2	0.77616	1.36275
WaterWear:DetergentBrandB:DaphniaClone3	-0.87443	1.36275
WaterWear:DetergentBrandC:DaphniaClone3	-1.03019	1.36275
WaterWear:DetergentBrandD:DaphniaClone3	-1.55400	1.36275

	t value	Pr(> t)
(Intercept)	5.835	4.48e-07
WaterWear	-0.232	0.81753
DetergentBrandB	-0.052	0.95883
DetergentBrandC	0.699	0.48794
DetergentBrandD	-0.314	0.75475
DaphniaClone2	0.728	0.46986
DaphniaClone3	3.016	0.00408
WaterWear:DetergentBrandB	0.482	0.63193
WaterWear:DetergentBrandC	-0.285	0.77712
WaterWear:DetergentBrandD	0.225	0.82255
WaterWear:DaphniaClone2	1.433	0.15835
WaterWear:DaphniaClone3	0.448	0.65627
DetergentBrandB:DaphniaClone2	0.954	0.34506
DetergentBrandC:DaphniaClone2	-0.170	0.86609
DetergentBrandD:DaphniaClone2	1.050	0.29884
DetergentBrandB:DaphniaClone3	-0.067	0.94658
DetergentBrandC:DaphniaClone3	-0.838	0.40597
DetergentBrandD:DaphniaClone3	-1.335	0.18809

```

WaterWear:DetergentBrandB:DaphniaClone2  -0.927  0.35837
WaterWear:DetergentBrandC:DaphniaClone2    0.995  0.32466
WaterWear:DetergentBrandD:DaphniaClone2    0.570  0.57164
WaterWear:DetergentBrandB:DaphniaClone3   -0.642  0.52414
WaterWear:DetergentBrandC:DaphniaClone3   -0.756  0.45337
WaterWear:DetergentBrandD:DaphniaClone3   -1.140  0.25980

```

```

(Intercept)                                ***

```

```

WaterWear

```

```

DetergentBrandB

```

```

DetergentBrandC

```

```

DetergentBrandD

```

```

DaphniaClone2

```

```

DaphniaClone3                                **

```

```

WaterWear:DetergentBrandB

```

```

WaterWear:DetergentBrandC

```

```

WaterWear:DetergentBrandD

```

```

WaterWear:DaphniaClone2

```

```

WaterWear:DaphniaClone3

```

```

DetergentBrandB:DaphniaClone2

```

```

DetergentBrandC:DaphniaClone2

```

```

DetergentBrandD:DaphniaClone2

```

```

DetergentBrandB:DaphniaClone3

```

```

DetergentBrandC:DaphniaClone3

```

```

DetergentBrandD:DaphniaClone3

```

```

WaterWear:DetergentBrandB:DaphniaClone2

```

```

WaterWear:DetergentBrandC:DaphniaClone2

```

```

WaterWear:DetergentBrandD:DaphniaClone2

```

```

WaterWear:DetergentBrandB:DaphniaClone3

```

```

WaterWear:DetergentBrandC:DaphniaClone3

```

```

WaterWear:DetergentBrandD:DaphniaClone3

```

```

---
```

```

Signif. codes:

```

```

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

```

```

Residual standard error: 0.8345 on 48 degrees of freedom

```

```

Multiple R-squared:  0.7147,    Adjusted R-squared:  0.578

```

```

F-statistic: 5.227 on 23 and 48 DF,  p-value: 7.019e-07

```

[Hide](#)

```
summary.aov(model2)
```

	Df	Sum Sq	Mean Sq	F value	Pr(>F)
Water	1	1.99	1.985	2.850	0.097838
Detergent	3	2.21	0.737	1.059	0.375478
Daphnia	2	39.18	19.589	28.128	8.23e-09
Water:Detergent	3	0.17	0.058	0.084	0.968608
Water:Daphnia	2	13.73	6.866	9.859	0.000259
Detergent:Daphnia	6	20.60	3.433	4.930	0.000532
Water:Detergent:Daphnia	6	5.85	0.975	1.399	0.234324
Residuals	48	33.43	0.696		

Water .

Detergent

Daphnia ***

Water:Detergent

Water:Daphnia ***

Detergent:Daphnia ***

Water:Detergent:Daphnia

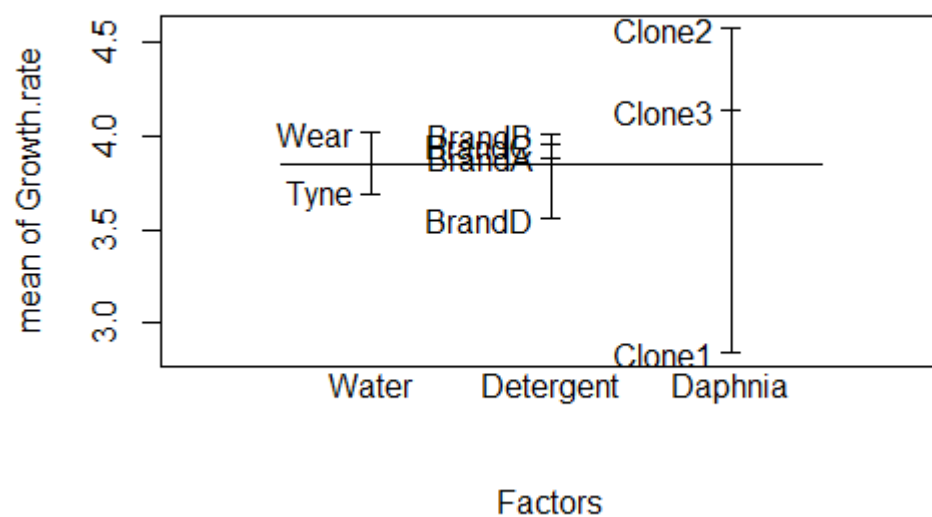
Residuals

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Hide

```
plot.design(Growth.rate~Water*Detergent*Daphnia)
```



Hide

```
model.tables(model1, "means", se = TRUE)
```

Tables of means

Grand mean

3.851905

Water

Water

Tyne Wear

3.686 4.018

Detergent

Detergent

BrandA BrandB BrandC BrandD

3.885 4.010 3.955 3.558

Daphnia

Daphnia

Clone1 Clone2 Clone3

2.840 4.577 4.139

Water:Detergent

Detergent

Water BrandA BrandB BrandC BrandD

Tyne 3.662 3.911 3.814 3.356

Wear 4.108 4.109 4.095 3.760

Water:Daphnia

Daphnia

Water Clone1 Clone2 Clone3

Tyne 2.868 3.806 4.383

Wear 2.812 5.348 3.894

Detergent:Daphnia

Daphnia

Detergent Clone1 Clone2 Clone3

BrandA 2.732 3.919 5.003

BrandB 2.929 4.403 4.698

BrandC 3.071 4.773 4.019

BrandD 2.627 5.214 2.834

Water:Detergent:Daphnia

, , Daphnia = Clone1

Detergent

Water BrandA BrandB BrandC BrandD

Tyne 2.811 2.776 3.288 2.597

Wear 2.653 3.082 2.855 2.656

, , Daphnia = Clone2

Detergent

Water BrandA BrandB BrandC BrandD

Tyne 3.308 4.191 3.621 4.106

```
Wear 4.530 4.615 5.925 6.322
```

```
, , Daphnia = Clone3
```

```
Detergent
```

```
Water BrandA BrandB BrandC BrandD
```

```
Tyne 4.867 4.766 4.535 3.366
```

```
Wear 5.140 4.630 3.504 2.303
```

```
Standard errors for differences of means
```

```
Water Detergent Daphnia Water:Detergent
```

```
0.1967 0.2782 0.2409 0.3934
```

```
replic. 36 18 24 9
```

```
Water:Daphnia Detergent:Daphnia
```

```
0.3407 0.4818
```

```
replic. 12 6
```

```
Water:Detergent:Daphnia
```

```
0.6814
```

```
replic. 3
```

Section 11.6

[Hide](#)

```
data <- read.table("Fungi.txt",header=T)
```

```
attach(data)
```

```
names(data)
```

```
[1] "Habitat" "Fugus.yield"
```

[Hide](#)

```
model <- aov(Fugus.yield~Habitat)
```

```
summary(model)
```

```
      Df Sum Sq Mean Sq F value Pr(>F)
Habitat    15    7527    501.8   72.14 <2e-16 ***
Residuals  144    1002     7.0
---
```

```
Signif. codes:
```

```
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

[Hide](#)

```
TukeyHSD(model)
```

Tukey multiple comparisons of means
95% family-wise confidence level

Fit: aov(formula = Fugus.yield ~ Habitat)

\$Habitat		diff	lwr	upr
Ash-Alder	3.53292777	-0.5808096	7.6466651	
Aspen-Alder	12.78574402	8.6720067	16.8994814	
Beech-Alder	12.32365349	8.2099161	16.4373908	
Birch-Alder	14.11348150	9.9997441	18.2272189	
Cherry-Alder	10.29508769	6.1813503	14.4088250	
Chestnut-Alder	12.24107899	8.1273416	16.3548163	
Holmoak-Alder	-1.44360558	-5.5573429	2.6701318	
Hornbeam-Alder	10.60271044	6.4889731	14.7164478	
Lime-Alder	19.19458205	15.0808447	23.3083194	
Oak-Alder	20.29457340	16.1808360	24.4083108	
Pine-Alder	14.34084715	10.2271098	18.4545845	
Rowan-Alder	6.29495226	2.1812149	10.4086896	
Spruce-Alder	-2.15119456	-6.2649319	1.9625428	
Sycamore-Alder	2.80900108	-1.3047363	6.9227384	
Willow-Alder	2.77635167	-1.3373857	6.8900890	
Aspen-Ash	9.25281625	5.1390789	13.3665536	
Beech-Ash	8.79072572	4.6769884	12.9044631	
Birch-Ash	10.58055373	6.4668164	14.6942911	
Cherry-Ash	6.76215993	2.6484226	10.8758973	
Chestnut-Ash	8.70815122	4.5944139	12.8218886	
Holmoak-Ash	-4.97653335	-9.0902707	-0.8627960	
Hornbeam-Ash	7.06978268	2.9560453	11.1835200	
Lime-Ash	15.66165428	11.5479169	19.7753916	
Oak-Ash	16.76164563	12.6479083	20.8753830	
Pine-Ash	10.80791938	6.6941820	14.9216567	
Rowan-Ash	2.76202449	-1.3517129	6.8757618	
Spruce-Ash	-5.68412232	-9.7978597	-1.5703850	
Sycamore-Ash	-0.72392669	-4.8376640	3.3898107	
Willow-Ash	-0.75657610	-4.8703135	3.3571613	
Beech-Aspen	-0.46209053	-4.5758279	3.6516468	
Birch-Aspen	1.32773748	-2.7859999	5.4414748	
Cherry-Aspen	-2.49065633	-6.6043937	1.6230810	
Chestnut-Aspen	-0.54466504	-4.6584024	3.5690723	
Holmoak-Aspen	-14.22934960	-18.3430870	-10.1156123	
Hornbeam-Aspen	-2.18303358	-6.2967709	1.9307038	
Lime-Aspen	6.40883803	2.2951007	10.5225754	
Oak-Aspen	7.50882938	3.3950920	11.6225667	
Pine-Aspen	1.55510312	-2.5586342	5.6688405	
Rowan-Aspen	-6.49079177	-10.6045291	-2.3770544	
Spruce-Aspen	-14.93693858	-19.0506759	-10.8232012	
Sycamore-Aspen	-9.97674295	-14.0904803	-5.8630056	
Willow-Aspen	-10.00939235	-14.1231297	-5.8956550	
Birch-Beech	1.78982801	-2.3239093	5.9035654	
Cherry-Beech	-2.02856580	-6.1423031	2.0851716	
Chestnut-Beech	-0.08257450	-4.1963119	4.0311629	
Holmoak-Beech	-13.76725907	-17.8809964	-9.6535217	

Hornbeam-Beech	-1.72094305	-5.8346804	2.3927943
Lime-Beech	6.87092856	2.7571912	10.9846659
Oak-Beech	7.97091991	3.8571826	12.0846573
Pine-Beech	2.01719366	-2.0965437	6.1309310
Rowan-Beech	-6.02870123	-10.1424386	-1.9149639
Spruce-Beech	-14.47484805	-18.5885854	-10.3611107
Sycamore-Beech	-9.51465241	-13.6283898	-5.4009151
Willow-Beech	-9.54730182	-13.6610392	-5.4335645
Cherry-Birch	-3.81839381	-7.9321312	0.2953435
Chestnut-Birch	-1.87240252	-5.9861399	2.2413348
Holmoak-Birch	-15.55708708	-19.6708244	-11.4433497
Hornbeam-Birch	-3.51077106	-7.6245084	0.6029663
Lime-Birch	5.08110055	0.9673632	9.1948379
Oak-Birch	6.18109190	2.0673545	10.2948293
Pine-Birch	0.22736565	-3.8863717	4.3411030
Rowan-Birch	-7.81852924	-11.9322666	-3.7047919
Spruce-Birch	-16.26467606	-20.3784134	-12.1509387
Sycamore-Birch	-11.30448042	-15.4182178	-7.1907431
Willow-Birch	-11.33712983	-15.4508672	-7.2233925
Chestnut-Cherry	1.94599129	-2.1677461	6.0597286
Holmoak-Cherry	-11.73869328	-15.8524306	-7.6249559
Hornbeam-Cherry	0.30762275	-3.8061146	4.4213601
Lime-Cherry	8.89949435	4.7857570	13.0132317
Oak-Cherry	9.99948571	5.8857484	14.1132231
Pine-Cherry	4.04575945	-0.0679779	8.1594968
Rowan-Cherry	-4.00013544	-8.1138728	0.1136019
Spruce-Cherry	-12.44628225	-16.5600196	-8.3325449
Sycamore-Cherry	-7.48608662	-11.5998240	-3.3723493
Willow-Cherry	-7.51873603	-11.6324734	-3.4049987
Holmoak-Chestnut	-13.68468457	-17.7984219	-9.5709472
Hornbeam-Chestnut	-1.63836854	-5.7521059	2.4753688
Lime-Chestnut	6.95350306	2.8397657	11.0672404
Oak-Chestnut	8.05349441	3.9397571	12.1672318
Pine-Chestnut	2.09976816	-2.0139692	6.2135055
Rowan-Chestnut	-5.94612673	-10.0598641	-1.8323894
Spruce-Chestnut	-14.39227354	-18.5060109	-10.2785362
Sycamore-Chestnut	-9.43207791	-13.5458153	-5.3183406
Willow-Chestnut	-9.46472732	-13.5784647	-5.3509900
Hornbeam-Holmoak	12.04631603	7.9325787	16.1600534
Lime-Holmoak	20.63818763	16.5244503	24.7519250
Oak-Holmoak	21.73817898	17.6244416	25.8519163
Pine-Holmoak	15.78445273	11.6707154	19.8981901
Rowan-Holmoak	7.73855784	3.6248205	11.8522952
Spruce-Holmoak	-0.70758898	-4.8213263	3.4061484
Sycamore-Holmoak	4.25260666	0.1388693	8.3663440
Willow-Holmoak	4.21995725	0.1062199	8.3336946
Lime-Hornbeam	8.59187160	4.4781343	12.7056090
Oak-Hornbeam	9.69186296	5.5781256	13.8056003
Pine-Hornbeam	3.73813670	-0.3756007	7.8518741
Rowan-Hornbeam	-4.30775819	-8.4214955	-0.1940208
Spruce-Hornbeam	-12.75390500	-16.8676424	-8.6401676
Sycamore-Hornbeam	-7.79370937	-11.9074467	-3.6799720
Willow-Hornbeam	-7.82635878	-11.9400961	-3.7126214
Oak-Lime	1.09999135	-3.0137460	5.2137287

Pine-Lime	-4.85373490	-8.9674723	-0.7399975
Rowan-Lime	-12.89962979	-17.0133671	-8.7858924
Spruce-Lime	-21.34577661	-25.4595140	-17.2320393
Sycamore-Lime	-16.38558097	-20.4993183	-12.2718436
Willow-Lime	-16.41823038	-20.5319677	-12.3044930
Pine-Oak	-5.95372625	-10.0674636	-1.8399889
Rowan-Oak	-13.99962114	-18.1133585	-9.8858838
Spruce-Oak	-22.44576796	-26.5595053	-18.3320306
Sycamore-Oak	-17.48557232	-21.5993097	-13.3718350
Willow-Oak	-17.51822173	-21.6319591	-13.4044844
Rowan-Pine	-8.04589489	-12.1596322	-3.9321575
Spruce-Pine	-16.49204170	-20.6057791	-12.3783043
Sycamore-Pine	-11.53184607	-15.6455834	-7.4181087
Willow-Pine	-11.56449548	-15.6782328	-7.4507581
Spruce-Rowan	-8.44614681	-12.5598842	-4.3324095
Sycamore-Rowan	-3.48595118	-7.5996885	0.6277862
Willow-Rowan	-3.51860059	-7.6323379	0.5951368
Sycamore-Spruce	4.96019563	0.8464583	9.0739330
Willow-Spruce	4.92754622	0.8138089	9.0412836
Willow-Sycamore	-0.03264941	-4.1463868	4.0810879

p adj

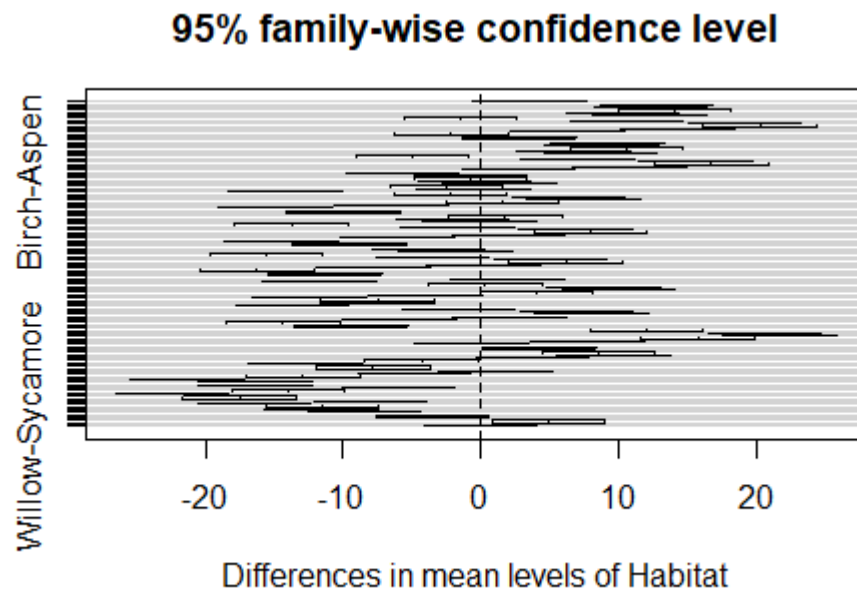
Ash-Alder	0.1844088
Aspen-Alder	0.0000000
Beech-Alder	0.0000000
Birch-Alder	0.0000000
Cherry-Alder	0.0000000
Chestnut-Alder	0.0000000
Holmoak-Alder	0.9975654
Hornbeam-Alder	0.0000000
Lime-Alder	0.0000000
Oak-Alder	0.0000000
Pine-Alder	0.0000000
Rowan-Alder	0.0000410
Spruce-Alder	0.9036592
Sycamore-Alder	0.5644643
Willow-Alder	0.5848838
Aspen-Ash	0.0000000
Beech-Ash	0.0000000
Birch-Ash	0.0000000
Cherry-Ash	0.0000065
Chestnut-Ash	0.0000000
Holmoak-Ash	0.0042690
Hornbeam-Ash	0.0000018
Lime-Ash	0.0000000
Oak-Ash	0.0000000
Pine-Ash	0.0000000
Rowan-Ash	0.5938269
Spruce-Ash	0.0003946
Sycamore-Ash	0.9999996
Willow-Ash	0.9999993
Beech-Aspen	1.0000000
Birch-Aspen	0.9990469
Cherry-Aspen	0.7546149
Chestnut-Aspen	1.0000000

Holmoak-Aspen	0.0000000
Hornbeam-Aspen	0.8929860
Lime-Aspen	0.0000264
Oak-Aspen	0.0000003
Pine-Aspen	0.9946232
Rowan-Aspen	0.0000191
Spruce-Aspen	0.0000000
Sycamore-Aspen	0.0000000
Willow-Aspen	0.0000000
Birch-Beech	0.9787523
Cherry-Beech	0.9381871
Chestnut-Beech	1.0000000
Holmoak-Beech	0.0000000
Hornbeam-Beech	0.9852674
Lime-Beech	0.0000042
Oak-Beech	0.0000000
Pine-Beech	0.9408763
Rowan-Beech	0.0001123
Spruce-Beech	0.0000000
Sycamore-Beech	0.0000000
Willow-Beech	0.0000000
Cherry-Birch	0.1011027
Chestnut-Birch	0.9682125
Holmoak-Birch	0.0000000
Hornbeam-Birch	0.1925375
Lime-Birch	0.0030585
Oak-Birch	0.0000633
Pine-Birch	1.0000000
Rowan-Birch	0.0000001
Spruce-Birch	0.0000000
Sycamore-Birch	0.0000000
Willow-Birch	0.0000000
Chestnut-Cherry	0.9558589
Holmoak-Cherry	0.0000000
Hornbeam-Cherry	1.0000000
Lime-Cherry	0.0000000
Oak-Cherry	0.0000000
Pine-Cherry	0.0592074
Rowan-Cherry	0.0661686
Spruce-Cherry	0.0000000
Sycamore-Cherry	0.0000003
Willow-Cherry	0.0000003
Holmoak-Chestnut	0.0000000
Hornbeam-Chestnut	0.9908681
Lime-Chestnut	0.0000030
Oak-Chestnut	0.0000000
Pine-Chestnut	0.9193954
Rowan-Chestnut	0.0001526
Spruce-Chestnut	0.0000000
Sycamore-Chestnut	0.0000000
Willow-Chestnut	0.0000000
Hornbeam-Holmoak	0.0000000
Lime-Holmoak	0.0000000
Oak-Holmoak	0.0000000

Pine-Holmoak	0.0000000
Rowan-Holmoak	0.0000001
Spruce-Holmoak	0.9999997
Sycamore-Holmoak	0.0349691
Willow-Holmoak	0.0380910
Lime-Hornbeam	0.0000000
Oak-Hornbeam	0.0000000
Pine-Hornbeam	0.1207078
Rowan-Hornbeam	0.0302058
Spruce-Hornbeam	0.0000000
Sycamore-Hornbeam	0.0000001
Willow-Hornbeam	0.0000001
Oak-Lime	0.9999007
Pine-Lime	0.0062590
Rowan-Lime	0.0000000
Spruce-Lime	0.0000000
Sycamore-Lime	0.0000000
Willow-Lime	0.0000000
Pine-Oak	0.0001484
Rowan-Oak	0.0000000
Spruce-Oak	0.0000000
Sycamore-Oak	0.0000000
Willow-Oak	0.0000000
Rowan-Pine	0.0000000
Spruce-Pine	0.0000000
Sycamore-Pine	0.0000000
Willow-Pine	0.0000000
Spruce-Rowan	0.0000000
Sycamore-Rowan	0.2019434
Willow-Rowan	0.1896363
Sycamore-Spruce	0.0044944
Willow-Spruce	0.0049788
Willow-Sycamore	1.0000000

[Hide](#)

```
plot(TukeyHSD(model))
```

[Hide](#)

```
pairwise.t.test(Fugus.yield,Habitat)
```

Pairwise comparisons using t tests with pooled SD

data: Fugus.yield and Habitat

	Alder	Ash	Aspen	Beech	Birch	Cherry
Ash	0.10011	-	-	-	-	-
Aspen	< 2e-16	6.3e-11	-	-	-	-
Beech	< 2e-16	5.4e-10	1.00000	-	-	-
Birch	< 2e-16	1.2e-13	1.00000	1.00000	-	-
Cherry	4.7e-13	2.9e-06	0.87474	1.00000	0.04943	-
Chestnut	< 2e-16	7.8e-10	1.00000	1.00000	1.00000	1.00000
Holmoak	1.00000	0.00181	< 2e-16	< 2e-16	< 2e-16	3.9e-16
Hornbeam	1.1e-13	8.6e-07	1.00000	1.00000	0.10057	1.00000
Lime	< 2e-16	< 2e-16	1.1e-05	1.9e-06	0.00131	3.3e-10
Oak	< 2e-16	< 2e-16	1.4e-07	2.0e-08	2.7e-05	1.9e-12
Pine	< 2e-16	3.9e-14	1.00000	1.00000	1.00000	0.02757
Rowan	1.8e-05	0.51826	8.5e-06	4.7e-05	3.9e-08	0.03053
Spruce	1.00000	0.00016	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Sycamore	0.50084	1.00000	2.1e-12	1.9e-11	3.3e-15	1.5e-07
Willow	0.51826	1.00000	1.9e-12	1.6e-11	2.8e-15	1.4e-07
	Chestnut	Holmoak	Hornbeam	Lime	Oak	Pine
Ash	-	-	-	-	-	-
Aspen	-	-	-	-	-	-
Beech	-	-	-	-	-	-
Birch	-	-	-	-	-	-
Cherry	-	-	-	-	-	-
Chestnut	-	-	-	-	-	-
Holmoak	< 2e-16	-	-	-	-	-
Hornbeam	1.00000	< 2e-16	-	-	-	-
Lime	1.4e-06	< 2e-16	1.3e-09	-	-	-
Oak	1.5e-08	< 2e-16	8.4e-12	1.00000	-	-
Pine	1.00000	< 2e-16	0.05975	0.00253	6.1e-05	-
Rowan	6.2e-05	5.3e-08	0.01380	< 2e-16	< 2e-16	1.5e-08
Spruce	< 2e-16	1.00000	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Sycamore	2.7e-11	0.01586	4.2e-08	< 2e-16	< 2e-16	1.1e-15
Willow	2.4e-11	0.01702	3.8e-08	< 2e-16	< 2e-16	9.3e-16
	Rowan	Spruce	Sycamore			
Ash	-	-	-			
Aspen	-	-	-			
Beech	-	-	-			
Birch	-	-	-			
Cherry	-	-	-			
Chestnut	-	-	-			
Holmoak	-	-	-			
Hornbeam	-	-	-			
Lime	-	-	-			
Oak	-	-	-			
Pine	-	-	-			
Rowan	-	-	-			
Spruce	2.5e-09	-	-			
Sycamore	0.10218	0.00187	-			
Willow	0.10057	0.00203	1.00000			

P value adjustment method: holm

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```
pairwise.t.test(Fugus.yield,Habitat,p.adjust.method="none")
```

Pairwise comparisons using t tests with pooled SD

data: Fugus.yield and Habitat

	Alder	Ash	Aspen	Beech	Birch	Cherry
Ash	0.00323	-	-	-	-	-
Aspen	< 2e-16	8.9e-13	-	-	-	-
Beech	< 2e-16	7.8e-12	0.69581	-	-	-
Birch	< 2e-16	1.4e-15	0.26218	0.13135	-	-
Cherry	5.9e-15	5.6e-08	0.03645	0.08761	0.00150	-
Chestnut	< 2e-16	1.1e-11	0.64494	0.94428	0.11461	0.10116
Holmoak	0.22299	4.3e-05	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Hornbeam	1.3e-15	1.6e-08	0.06625	0.14673	0.00342	0.79462
Lime	< 2e-16	< 2e-16	2.3e-07	3.6e-08	3.0e-05	4.7e-12
Oak	< 2e-16	< 2e-16	2.4e-09	3.2e-10	5.6e-07	2.5e-14
Pine	< 2e-16	4.7e-16	0.18945	0.08938	0.84742	0.00079
Rowan	3.6e-07	0.02057	1.7e-07	1.0e-06	6.3e-10	0.00090
Spruce	0.07026	3.6e-06	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Sycamore	0.01855	0.54035	2.8e-14	2.6e-13	< 2e-16	2.7e-09
Willow	0.01993	0.52226	2.4e-14	2.2e-13	< 2e-16	2.3e-09
	Chestnut	Holmoak	Hornbeam	Lime	Oak	Pine
Ash	-	-	-	-	-	-
Aspen	-	-	-	-	-	-
Beech	-	-	-	-	-	-
Birch	-	-	-	-	-	-
Cherry	-	-	-	-	-	-
Chestnut	-	-	-	-	-	-
Holmoak	< 2e-16	-	-	-	-	-
Hornbeam	0.16697	< 2e-16	-	-	-	-
Lime	2.5e-08	< 2e-16	2.0e-11	-	-	-
Oak	2.2e-10	< 2e-16	1.1e-13	0.35260	-	-
Pine	0.07715	< 2e-16	0.00187	6.5e-05	1.3e-06	-
Rowan	1.4e-06	9.0e-10	0.00036	< 2e-16	< 2e-16	2.3e-10
Spruce	< 2e-16	0.54952	< 2e-16	< 2e-16	< 2e-16	< 2e-16
Sycamore	3.8e-13	0.00043	7.1e-10	< 2e-16	< 2e-16	< 2e-16
Willow	3.3e-13	0.00047	6.1e-10	< 2e-16	< 2e-16	< 2e-16
	Rowan	Spruce	Sycamore			
Ash	-	-	-			
Aspen	-	-	-			
Beech	-	-	-			
Birch	-	-	-			
Cherry	-	-	-			
Chestnut	-	-	-			
Holmoak	-	-	-			
Hornbeam	-	-	-			
Lime	-	-	-			
Oak	-	-	-			
Pine	-	-	-			
Rowan	-	-	-			
Spruce	3.8e-11	-	-			
Sycamore	0.00365	4.6e-05	-			
Willow	0.00335	5.1e-05	0.97796			

P value adjustment method: none

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```
install.packages("multcomp")
```

WARNING: Rtools is required to build R packages but is not currently installed. Please download and install the appropriate version of Rtools before proceeding:

<https://cran.rstudio.com/bin/windows/Rtools/>

Installing package into 恔恔C:/Users/Nathan/Documents/R/win-library/3.6恔恔

(as 恔恔lib恔恔 is unspecified)

also installing the dependencies 恔恔zoo恔恔, 恔恔mvtnorm恔恔, 恔恔TH.data恔恔, 恔恔sandwich恔恔

trying URL 'https://cran.rstudio.com/bin/windows/contrib/3.6/zoo_1.8-6.zip'

Content type 'application/zip' length 1103803 bytes (1.1 MB)

downloaded 1.1 MB

trying URL 'https://cran.rstudio.com/bin/windows/contrib/3.6/mvtnorm_1.0-11.zip'

Content type 'application/zip' length 271942 bytes (265 KB)

downloaded 265 KB

trying URL 'https://cran.rstudio.com/bin/windows/contrib/3.6/TH.data_1.0-10.zip'

Content type 'application/zip' length 8487682 bytes (8.1 MB)

downloaded 8.1 MB

trying URL 'https://cran.rstudio.com/bin/windows/contrib/3.6/sandwich_2.5-1.zip'

Content type 'application/zip' length 1382340 bytes (1.3 MB)

downloaded 1.3 MB

trying URL 'https://cran.rstudio.com/bin/windows/contrib/3.6/multcomp_1.4-10.zip'

Content type 'application/zip' length 730914 bytes (713 KB)

downloaded 713 KB

package 'zoo' successfully unpacked and MD5 sums checked

package 'mvtnorm' successfully unpacked and MD5 sums checked

package 'TH.data' successfully unpacked and MD5 sums checked

package 'sandwich' successfully unpacked and MD5 sums checked

package 'multcomp' successfully unpacked and MD5 sums checked

The downloaded binary packages are in

C:\Users\Nathan\AppData\Local\Temp\RtmpqW2mFi\downloaded_packages

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Section 11.7

```
data <- read.table("manova.txt",header=T)
```

```
attach(data)
names(data)
```

```
[1] "tear"      "gloss"      "opacity"    "rate"       "additive"
```

[Hide](#)

```
Y <- cbind(tear, gloss, opacity)
```

```
model <- manova(Y~rate*additive)
summary(model)
```

```
              Df  Pillai approx F num Df den Df    Pr(>F)
rate           1 0.61814   7.5543     3    14 0.003034 **
additive        1 0.47697   4.2556     3    14 0.024745 *
rate:additive   1 0.22289   1.3385     3    14 0.301782
Residuals      16
---
Signif. codes:
0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1
```

[Hide](#)

```
summary.aov(model)
```

Response tear :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
rate	1	1.7405	1.74050	15.7868	0.001092	**
additive	1	0.7605	0.76050	6.8980	0.018330	*
rate:additive	1	0.0005	0.00050	0.0045	0.947143	
Residuals	16	1.7640	0.11025			

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response gloss :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
rate	1	1.3005	1.30050	7.9178	0.01248	*
additive	1	0.6125	0.61250	3.7291	0.07139	.
rate:additive	1	0.5445	0.54450	3.3151	0.08740	.
Residuals	16	2.6280	0.16425			

Signif. codes:

0 '***' 0.001 '**' 0.01 '*' 0.05 '.' 0.1 ' ' 1

Response opacity :

	Df	Sum Sq	Mean Sq	F value	Pr(>F)	
rate	1	0.421	0.4205	0.1036	0.7517	
additive	1	4.901	4.9005	1.2077	0.2881	
rate:additive	1	3.960	3.9605	0.9760	0.3379	
Residuals	16	64.924	4.0578			